# Printable nanomaterials for flexible electronics

Kuniharu Takei
Dept. of Physics and Electronics,
Osaka Prefecture University
Sakai, Osaka 599-8531, JAPAN
takei@pe.osakafu-u.ac.jp

Nanomaterials are of tremendous interest due to their unique fundamental properties. In fact, there have been many reports on nanomaterial-based electronic devices for a variety of applications such as transistors, sensors, and actuators etc. One of the bottlenecks and challenges however is a patterning and an integration of nanomaterials to move forward into practical applications. In this talk, uniformly patterned printable nanomaterials will be discussed toward macro-scale flexible integrated electronics to address the issue. Especially this talk will be focused on inorganic semiconductor nanowires[1,2], carbon nanotubes[3,4], and hybrid nanomaterial films patterned by our developed printing techniques.

As examples of printable nanomaterial devices, we have developed artificial electronic skin and whisker based on printed one-dimensional nanowires/nanotubes and hybrid nano-composite film, respectively. They exhibited that the field-effect mobility of transistor using semiconductor carbon nanotube network film is >30 $cm^2$/Vs on a flexible substrate, allowing us to operate electronics at low voltage below <5V. The artificial electronic whiskers enable to detect low pressure around 1 Pa by making a unique structure, resulting in that it can detect wind flow like rat whiskers. Furthermore, three dimensional gas flow (<5 Psi) mapping was successfully demonstrated.

This patterning and integration technique developed can be applied to many types of nanomaterials and substrates. In addition to the flexible devices, we have also reported high performance III-V semiconductor transistors with the effective mobility >4000 $cm^2$/Vs directly fabricated on $Si/SiO_2$ substrates[5,6]. This explains that the technique is universal, addressing the fundamental challenge of nanomaterial patterning and integration.

These works were mainly accomplished with Professor Ali Javey at University of California, Berkeley.

References:

1. Z. Fan et al., Advanced Materials, 21, 3730, 2009.
2. K. Takei et al., Nature Materials, 9, 821, 2010.
3. T. Takahashi et al., Nano Letters, 11, 5408, 2011.
4. C. Wang et al., Nano Letters, 12, 1527, 2012.
5. H. Ko et al., Nature, 468, 286, 2010.
6. K. Takei et al., Nano Letters, 12, 2060, 2012.